

Before the Office of Administrative Hearings
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St. Paul, MN 55101

For the Minnesota Public Utilities Commission
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In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under
Minnesota Statute 216B.2422, Subdivision 3

MPUC Docket No. E-999/CI-14-643
OAH Docket No. 80-2500-31888

**Initial Brief of Great River Energy,
Minnesota Power, and Otter Tail Power Company**

Carbon Dioxide

November 24, 2015

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I. INTRODUCTION

Great River Energy, Minnesota Power, and Otter Tail Power Company (collectively, “GRE/MP/OTP”) are electric utilities which together serve approximately 865,000 customers throughout most of greater Minnesota. We are committed to providing reliable and affordable service to our customers. We each have also taken significant steps to decrease our dependence on coal generation. We recognize the significant role played by the quantification of environmental cost values in the State of Minnesota’s resource planning process. Accordingly, we have participated in this proceeding and we jointly submit this initial brief regarding the updating of the environmental cost value for carbon dioxide (“CO₂”).

We believe the record establishes by a preponderance of the evidence that the Federal Social Cost of Carbon, as proposed the Minnesota Department of Commerce, Division of Energy Resources and the Minnesota Pollution Control Agency (the “Agencies”) and the coalition of environmental groups called “Clean Energy Organizations” (the “CEOs”), is not a reasonable measure to rely upon to update the CO₂ value for at least the following reasons:

- The Federal Social Cost of Carbon was not designed to be used in resource planning;
- The Integrated Assessment Models (“IAMs”) used to develop the Federal Social Cost of Carbon create a perception of knowledge and precision that is illusory and they cannot provide the type of precision required to “quantify” environmental cost values; and
- The damage estimates produced by the Federal Social Cost of Carbon are highly speculative.

We believe the evidence in the record convincingly shows the Federal Social Cost of Carbon is not a reasonable measure for updating the range of CO₂ values. However, if the

Commission were to determine otherwise, we strongly urge it to adopt a modified version of the Federal Social Cost of Carbon, consistent with the economic framing assumptions that the Commission has previously found appropriate for establishing Minnesota’s environmental cost values. The proponents of the Federal Social Cost of Carbon are in effect requesting the Commission to reverse its prior determinations regarding three key economic framing assumptions: time horizon, discount rate and marginal ton. The Federal Social Cost of Carbon is contrary to past Commission determinations insofar as it extends the modeling time horizon by nearly 200 years, includes an interest rate of less than 3 percent, and converts to a new form of marginal ton analysis based on the last ton of emissions. In addition to being contrary to Commission precedent, we believe the adoption of the Federal Social Cost of Carbon, as proposed, would neither comply with statutory requirements nor be in the public interest.

As a better alternative, we recommend the Commission adopt a modified version of the Federal Social Cost of Carbon as proposed by Anne E. Smith, Ph.D. Dr. Smith ran the same IAMs used by the Interagency Working Group (“IWG”) with modified economic framing assumptions more appropriate for determining Minnesota’s environmental cost values. She did so without changing any of the ways in which the IAMs simulate the physical science aspects of the models, such as the relationship between carbon emissions levels and temperature change. Based on her work, Dr. Smith recommended a range of \$1.62 per net tonne to \$5.14/net tonne (2014\$ for emission year 2020).¹

¹ Ex. 300 at 33:14-15; 31 Table 4 (Smith Direct). Like the IWG has done with the Federal Social Cost of Carbon, Dr. Smith in her report and testimony provides her estimates in metric tons. Dr. Smith has used the spelling “tonne” in her testimony and report to make it clear she is not referring to the short ton. *Id.* at 34:20-35:3 (Smith Direct). To convert metric tons to short tons, you should multiply the number of metric tons by 1.10231131. To convert short tons to metric tons, multiply the number of short tons by .90718474.

II. PROCEDURAL HISTORY

On October 9, 2013, the CEOs² petitioned the Commission to update the environmental cost value ranges.³ The CEOs specifically recommended the Commission adopt the IWG's Federal Social Cost of Carbon as Minnesota's environmental cost value for CO₂.⁴

On February 10, 2014, the Commission issued an order in Docket No. E-999/CI-00-1636 reopening its investigation into environmental costs of different methods of generating electricity under Minn. Stat. §216B.2422, subd. 3. Before referring the matter to the Office of Administrative Hearings ("OAH"), the Commission sought input on the scope of the investigation, whether to retain an expert, and the possible role of an expert from a stakeholder group led by the Agencies.

On June 10, 2014, the Agencies filed their report on the conclusions reached by the stakeholder group.⁵ The Agencies reported there was little consensus among the stakeholders

² The CEOs originally consisted of Minnesota Center for Environmental Advocacy, Fresh Energy, Isaac Walton League of America – Midwest Office, and the Sierra Club. *See In the Matter of the Quantification of Environmental Costs*, Docket No. E-999/CI-93-583, Notice of Motion and Motion to Update Externality Values for Use in Resource Decisions (Oct. 9, 2013). Isaac Walton League of America – Midwest Office withdrew as a party on October 30, 2015. *In the Matter of the Further Investigation into Environmental and Socioeconomic Costs under Minn. Stat. § 216B.2422, Subdivision 3*, Docket No. E-999/CI-14-643, Notice of Appearance (Oct. 30, 2015).

³ *In the Matter of the Quantification of Environmental Costs*, Docket No. E-999/CI-93-583, Memorandum in Support of Clean Energy Organization's Motion to Update Externality Values for Use in Resource Decisions (Oct. 9, 2013) at 1-2.

⁴ *Id.* at 18-19.

⁵ *See In the Matter the Investigation into Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3*, Docket No. E-999/CI-00-1636, Comments of the Minnesota Department of Commerce, Division of Energy Resources and the Minnesota Pollution Control Agency (June 10, 2014).

regarding the scope and process for the investigation or whether an expert should be retained.⁶

In the same report, the Agencies proposed on their own volition and without consulting with the other stakeholders that the Commission should adopt the Federal Social Cost of Carbon midpoint values for CO₂, which had been recently developed by the federal government for use in federal regulatory impact analyses.⁷

On June 16, 2014, the Commission requested comments on the Agencies' report and recommendations. Comments were received from GRE/MP/OTP, the CEOs, the State of North Dakota, Xcel Energy, Lignite Energy Council, Minnesota Large Industrial Group, the Minnesota Chamber of Commerce, and Peabody Energy Corporation.

On September 4, 2014, the matter came before the Commission. Thereafter, on October 15, 2014, the Commission issued its order that referred the issue of the appropriate values for CO₂, as well as for the criteria pollutants PM_{2.5}, SO₂ and NO_x, under Minn. Stat. § 216B.2422, subd. 3, to the OAH for contested case proceedings.⁸ In doing so, the Commission ordered the parties to “specifically and thoroughly address” the following issues with respect to updating the CO₂ values: (1) “[w]hether the Federal Social Cost of Carbon is reasonable and the best available measure to determine the environmental cost of CO₂ . . . ; and (2) “if not, what measure is better supported by the evidence.”⁹

In the first pre-hearing order issued on December 9, 2014, this contested case was separated into two tracks so that testimony concerning CO₂ was filed separately from that

⁶ *Id.* at 3.

⁷ *Id.* at 9-10.

⁸ *In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. 216B.2422, Subdivision 3*, PUC Docket Nos. E-999/CI-00-1636, E999/CI-14-643, Notice and Order for Hearing (Oct. 15, 2014) (“Notice and Order for Hearing”), at 8.

⁹ *Id.* at 5.

concerning the environmental cost values for the criteria pollutants.¹⁰ Direct pre-filed testimony for CO₂ was filed on June 1, 2015, rebuttal testimony was filed on August 12, 2015, and surrebuttal testimony was filed on September 10, 2015. The evidentiary hearing for the CO₂ phase was held on September 24-25, and 28-30, 2015.

III. APPLICABLE LAW AND COMMISSION PRECEDENT

Section 216B.2422 of the Minnesota Statutes requires Minnesota utilities to file resource plans with the Commission setting out resource options to meet the service needs of their customers. The Commission must review and approve, accept, reject, or modify those plans based on the public interest. Subdivision 3(a) of Section 216B.2422 provides the Commission “shall, to the extent practicable, quantify and establish a range of environmental costs associated with each method of electricity generation.”¹¹ Utilities are required to use the values established by the Commission, in conjunction with other factors, when evaluating and selecting resource options in Commission proceedings, including in resource planning and certificate of need dockets.¹²

The statutory requirements that the Commission “quantify and establish” the range of environmental cost values and that it do so “to the extent practicable” provides meaningful directives for this proceeding. To have any significant effect, the practicability requirement must turn on whether it is possible for the Commission to “quantify and establish” a range of

¹⁰ *In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. 216B.2422, Subdivision 3*, PUC Docket Nos. E-999/CI-00-1636, E999/CI-14-643, First Prehearing Order (Dec. 9, 2014). A public hearing was held on August 26, 2015, and the deadline for public comments was September 18, 2015. At the public hearing and in their written comments, the public was allowed to comment on the values for both criteria pollutants and CO₂.

¹¹ Paragraph (b) of Minn. Stat. 216B.2422, subd. 3, which is not relevant to these proceedings, required the Commission to establish interim environmental cost values by March 1, 1994.

¹² *Id.*

environmental cost values with a reasonable evidentiary basis. Quantification suggests the Commission is to consider and add up environmental damages in arriving at the range of values. The requirement that the Commission is to “quantify” the range of environmental cost values thus imports a requirement that the Commission base its range of values on evidence of measurable costs.¹³ It is clearly not enough to simply conjure up ranges of dollar figures to use in resource planning based upon guesswork or crude approximations.¹⁴

In the past, the Commission has clearly required a reasonable evidentiary basis for proposed values and it has rejected proposed values when they were found to be based on highly speculative estimates.¹⁵ While it has recognized there will be some level of uncertainty associated with damage estimates, the Commission has insisted that the “available data . . . provide a sufficiently reliable basis for estimating environmental damage.”¹⁶ In fact, the Commission rejected, as recommended by Administrative Law Judge Klein, the higher of the two damage functions proposed by the Minnesota Pollution Control Agency’s witness because it was “factually unsupported by the record” and was “highly speculative given the available evidence.”¹⁷ As Judge Klein recognized, the “to the extent practicable” condition should be read

¹³ See, e.g., *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3*, Docket No. E-999/CI-93-583, Finding of Fact, Conclusions, Recommendation and Memorandum (Mar. 22, 1996) (“ALJ Findings”) at ¶ 144 (noting that there was insufficient evidence in the record to quantify damages from mercury emissions).

¹⁴ *Id.* at ¶¶ 142, 144 (concluding a “rough estimate” was insufficient to quantify damages from mercury emissions).

¹⁵ See *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3*, Docket No. E-999/CI-93-583, Order Establishing Environmental Cost Values (Jan. 3, 1997) (“January 3, 1997 Commission Order”) at 26.

¹⁶ *Id.*

¹⁷ *Id.* at 27.

to “refer to consideration of the sufficiency of the data or level of uncertainty involved in quantifying values.”¹⁸ “At some point, the degree of uncertainty associated with a proposed value becomes so great that there is insufficient evidence to meet the preponderance standard, and the value cannot be adopted.”¹⁹ Given the uncertainty involved in establishing environmental cost values and the resulting risk of over-estimation, Judge Klein also recommended the Commission adopt conservative values.²⁰

In the proceeding that lead to the initial establishment of final values in 1997, both the Commission and the Judge Klein recognized that environmental cost value ranges should not be established when the cost of environmental damages cannot be adequately quantified, which was the case at that time with respect to mercury emissions. The Commission recognized that mercury undoubtedly causes damage and that coal burning, including coal burning at electrical generation stations, was the leading source of mercury emissions in Minnesota.²¹ Nonetheless, the Commission did not set a range of environmental cost values for mercury emissions because there was too much uncertainty regarding the amount of damages. The Commission recognized “the legislature’s directive that the Commission is to quantify values only if (to the extent) it is feasible (practicable) to do so.”²² The Commission explained that some level of uncertainty may be acceptable and therefore “practicable” to quantify environmental values, but that “there is also

¹⁸ ALJ Findings at ¶ 16.

¹⁹ *Id.* at ¶31.

²⁰ *Id.* at Discussion of Policy Issues section, at pp. 17-18 of 47 of pdf file.

²¹ January 3, 1997 Commission Order at 28.

²² *Id.* at 31.

a point on the uncertainty continuum where it becomes infeasible to quantify environmental costs even though the Commission is convinced that such costs exist.”²³

Applying these common-sense principles that values should be supported by reasonable evidence and should not be based on highly speculative evidence, the Commission rejected a proposed damage function which went beyond the evidence in an attempt to include a risk premium, and adopted a more conventional approach in which the range of values for carbon dioxide was based on the damage estimated to be caused by an average ton of emitted carbon dioxide through to the year 2100.²⁴ That damage was discounted to a present value, and there was some controversy regarding the appropriate discount rate, as there is in this proceeding.²⁵ The Commission was urged to use low discount rates under the theory, associated with economist William Cline in that docket, that low discount rates are appropriate when discounting across generations.²⁶ However, the Commission determined there was insufficient support for that position and held the weight of the evidence in the record supported the use of 3 percent and 5 percent discount rates.²⁷

²³ *Id.* at 30. The inability to quantify a specific environmental cost with sufficient certainty was not the equivalent of ignoring it in resource planning. Instead, the Commission and other parties in resource planning dockets could continue to consider such unquantified impacts on a qualitative basis. ALJ Findings at Discussion of Policy Issues section, at pp. 17-18 of 47 of pdf file.

²⁴ January 3, 1997 Commission Order at 27.

²⁵ ALJ Findings at ¶ 107.

²⁶ *Id.* at ¶ 111; January 3, 1997 Commission Order at 27.

²⁷ January 3, 1997 Commission Order at 27.

IV. BURDEN AND STANDARD OF PROOF

As Administrative Law Judge Schlatter determined in the Order Regarding Burdens of Proof, the appropriate standard of proof in this proceeding is the preponderance of the evidence.²⁸ In its appellate review of the 1990s proceeding, the Minnesota Court of Appeals determined the preponderance of the evidence was the appropriate standard,²⁹ and in the absence of any other applicable standard of proof it is the standard required under the applicable rule.³⁰

Accordingly, any party proposing the Commission adopt an environmental cost value (or range of values) for CO₂, including the Federal Social Cost of Carbon, bears the burden of proving by a preponderance of the evidence that the value or values proposed are reasonable and the best available measure.³¹ The preponderance of the evidence standard is satisfied by proof which leads the finder of fact to find the existence of the contested fact or issue is more probable than not.³² If evidence of a fact or issue is equally balanced, then the fact or issue has not been established by a preponderance of the evidence.³³ A party opposing a value or range of values

²⁸ *In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3*, PUC Docket No. E-999/CI-14-643, OAH Docket No. 80-2500-31888, Order Regarding Burdens of Proof (Mar. 27, 2015) (“Order on Burden of Proof”) at 2.

²⁹ *In re Quantification of Env’t Costs*, 578 N.W.2d 794, 801 (Minn. Ct. App. 1998).

³⁰ Minn. R. 1400.7300 (“party proposing that certain action be taken must prove the facts at issue by a preponderance of the evidence”.)

³¹ Order on Burden of Proof at 2.

³² *City of Lake Elmo v. Metro. Council*, 685 N.W.2d 1, 4 (Minn. 2004) (citation omitted).

³³ *Id.*

must demonstrate, at a minimum, that the evidence offered in support of the value or values has not satisfied the preponderance of the evidence standard.³⁴

In this proceeding, the proponents of the adoption of the Federal Social Cost of Carbon must present evidence which makes it more probable than not that the Federal Social Cost of Carbon is a reasonable and the best available measure of the environmental cost of CO₂. To prevail, they must demonstrate the Federal Social Cost of Carbon satisfies the substantive law “practicability of quantification” standard. To do so, they must show by a preponderance of the evidence that the values produced by the Federal Social Cost of Carbon have an adequate evidentiary basis and are sufficiently certain. The same burden and standard of proof must be met by proponents of alternatives to the Federal Social Cost of Carbon.

V. ARGUMENT

A. The Federal Social Cost of Carbon is Neither a Reasonable Nor the Best Available Measure to Determine the CO₂ Environmental Cost Value.

The adoption of the Federal Social Cost of Carbon would be a major departure from the measure currently used by the Commission to determine the CO₂ value in at least two major respects. First, the Federal Social Cost of Carbon places great faith in three IAMs - DICE, FUND and PAGE - developed in the 1990s to estimate Gross Domestic Product (“GDP”) losses caused by global temperature changes. Neither the IAMs nor the Federal Social Cost of Carbon were designed to provide the level of precision required to quantify environmental cost values for use in a single state’s resource planning. Although some believe it may be tempting to see the Federal Social of Carbon as a pre-fabricated, ready-to-go measure to set cost values for use in Minnesota resource planning, the evidence shows it is poorly suited for site-specific decision-making. Second, three of the four key economic framing assumptions used in the Federal Social

³⁴ *Id.* at 3, 6.

Cost of Carbon differ from those used by the Commission when it previously determined the CO₂ range of values and are not consistent with the Commission's precedent. At the very least, the Commission should only rely on the Federal Social Cost of Carbon if modifications are made so the updated values align with the Commission's prior economic framing assumptions.

1. The Federal Social Cost of Carbon was not designed for use in resource planning.

The IWG relied on the IAMs to develop the Federal Social Cost of Carbon. As with any model, it is imperative to consider the limits of the IAMs, as well as the underlying framing assumptions employed by the IWG in its use of the IAMs. The IAMs were an early attempt to integrate climate science with the economic effects of greenhouse gas emissions.³⁵ They have proven valuable in helping policy-makers understand how greenhouse gas emissions accumulate in the atmosphere, how that accumulation can affect global mean temperatures, and how higher temperatures might affect GDP and consumption.³⁶ But the IAMs are not well-suited for quantitative policy analysis. The IAMs are reduced-form mathematical models driven by an aggregated "damages function" rather than by the traditional effect-by-effect approach used in most damage cost analyses.³⁷ They were developed for use in the broad context of global climate policy, but there is a lack of clear theoretical or empirical bases for the damages functions used in the IAMs, and they depend heavily on virtually pure speculation regarding future emissions and damages.³⁸ Consequently, the IAM-based Federal Social Cost of Carbon may create an illusory and misleading appearance of knowledge and precision about the benefits

³⁵ Ex. 100, Schedule 2 at 5 n.2 (Polasky Direct Schedule 2, 2010 TSD).

³⁶ *Id.* at 5.

³⁷ Ex. 300 at 19:4-15 (Smith Direct).

³⁸ Ex. 302 at 71-72 (Smith Report).

of reducing CO₂ emissions. IAMs were simply not designed and are in many ways poorly suited to quantify the precise values required for resource planning.³⁹ They must be used, if used at all, with extreme caution.

There is no dispute that the Federal Social Cost of Carbon was developed for federal regulatory impact analysis. The IWG has clearly stated the Federal Social Cost of Carbon was developed for that purpose.⁴⁰ The IWG has also pointed out that it has not addressed the use of the Federal Social Cost of Carbon estimates outside the regulatory context, such as in NEPA analysis, state-level decision making, and ‘pricing’ carbon in the marketplace.⁴¹ Putting it in the context of this proceeding, Dr. Smith observed that the IWG did not design the Federal Social Cost of Carbon for use in making project-specific decisions or policymaking at the state level.⁴²

The record evidence also establishes that, whatever merits it may have for purposes in the broad context of federal regulatory impact analysis, the Federal Social Cost of Carbon is not suited for the finer-grained decision-making involved in utility resource planning in Minnesota.⁴³ The key distinction between the two applications is that imprecision and potential overestimation is less of a concern when the Federal Social Cost of Carbon is used for its intended purpose.⁴⁴ The Federal government is not using Federal Social Cost of Carbon to determine how to regulate

³⁹ Ex. 101, Schedule 1 at 41 (Polasky Rebuttal Schedule 1, Response to Comments); Ex. 600 at 13:13-14:4 (Martin Direct).

⁴⁰ Ex. 101, Schedule 1 at 40 (Polasky Rebuttal Schedule 1, Response to Comments).

⁴¹ *Id.* at 41.

⁴² Hearing Transcript, Vol. 2A, 55:14-20 (Smith).

⁴³ Ex 304 at 14:10-14 (Smith Surrebuttal); Ex. 602 at 7:8-8:7 (Martin Surrebuttal).

⁴⁴ Ex. 602 at 7:8-8:7 (Martin Surrebuttal).

in a particular area or to decide exactly how stringent particular regulations should be.⁴⁵ In regulatory impact analysis, the range of values is used to perform cost-benefit analyses of proposed regulations.⁴⁶ The question considered in a regulatory impact analysis is whether it makes sense to enact the proposed regulation in view of the estimated costs and benefits.⁴⁷ In that context, a great amount of imprecision and potential over-counting is not as problematic as it would be in site-specific resource planning.⁴⁸

To make this point, Nicholas Martin, witness for Xcel Energy, made a comparison between analyses of the CO₂ benefits resulting from President Obama's Clean Power Plan and the evaluation of a power plant as a future generation source during Minnesota's resource planning process. The government performed regulatory impact analyses of the Clean Power Plan using a range of Federal Social Cost of Carbon values of approximately \$12 to \$120, and the proposed regulatory scheme "passed" the cost-benefit test under both extremes.⁴⁹ In this context, the lack of precision with regard to the cost associated with a ton of carbon emissions was not important. In contrast, the difference between \$12 and \$120 per ton of carbon dioxide emitted is quite important in utility resource planning.⁵⁰ Those values could have drastically

⁴⁵ Ex. 600 at 13:3-11 (Martin Direct).

⁴⁶ *Id.* at 6:3-8.

⁴⁷ *Id.*

⁴⁸ *Id.* at 6:10-19.

⁴⁹ Ex. 602 at 7:16-25; 8:11-19 (Martin Surrebuttal); Hearing Transcript, Vol. 4A, 73:17-75:1 (Martin).

⁵⁰ Hearing Transcript, Vol. 4A, at 73:17-75:1 (Martin).

different impacts on a utility's resource plan and the ultimate decisions regarding generation assets.⁵¹

The decisions made in individual resource plan dockets about continuing to operate, retrofit, or even retire power plants are usually irreversible and tremendously expensive.⁵² Commission rate-regulated utilities could perhaps be made whole even if an inefficient decision were to be made as a result of a faulty and imprecise environmental cost value, provided rate recovery is achieved (though there is no certainty on that point and the reactions of regulators in other states must be considered), but Minnesota citizens and consumers could be impacted. Higher environmental cost for CO₂ based on speculative evidence could result in resource decisions that lead to higher bills for consumers.⁵³ Consumers and industries that use a great deal of electricity, such as those included in the group of large industrial consumers participating in this docket, could be particularly impacted by such rate increases. Moreover, if environmental cost values are set too high and result in relatively expensive resource decisions, "leakage" could result, driving future energy production and jobs elsewhere.⁵⁴

Minnesota's environmental cost values are included as a sensitivity in resource planning that may be facility-specific and have critical long-term consequences for the state's power supply. If used as a primary determinant in making resource decisions, the values may impact whether particular power plants are built, closed, or modified to use another fuel. Accordingly,

⁵¹ Ex. 602 at 8:24-9:1 (Martin Surrebuttal).

⁵² Hearing Transcript, Vol. 4A, at 75:5-25.

⁵³ Hearing Transcript, Vol. 4A, at 16:21-18:20.

⁵⁴ Ex. 302 at 104 (Smith Report) (noting leakage is likely to occur); Ex. 601 at 52:15-53:5 (Martin Rebuttal) (noting leakage is likely to occur); Ex. 218 at 4:55-60 (Mendelsohn Rebuttal Report); *see also* Hearing Transcript, Vol. 1 at 125:20-126:9 (Polasky) (leakage should be taken into account in resource planning).

as the Commission has recognized, it must carefully and thoughtfully adopt reasonably accurate, evidentiary-based ranges of environmental cost values.

2. The Federal Social Cost of Carbon is poorly suited for use in resource planning because the IAMs used to develop the Federal Social Cost of Carbon cannot provide the level of precision in the quantification of values required for resource planning.

The Federal Social Cost of Carbon also suffers from significant “uncertainty, speculation, and lack of information” with respect to the way in which it translates environmental impacts into economic damages.⁵⁵ In order to determine the Federal Social Cost of Carbon, the IWG generated estimates of the economic damages resulting from predicted warming using the IAMs’ “damage functions.” The IWG recognized that the representations reflected in the IAMs’ damage functions are “incomplete and highly uncertain.”⁵⁶ The IWG also noted the “need for a thorough review of damage functions”⁵⁷ The IWG’s observations have been confirmed by evidence offered in this proceeding. The damage functions used in the IAMs suffer from two distinct problems. First, they contain highly aggregated, simplified formulas that do not model relationships between warming effects and damages. Second, they are extrapolated from old and limited data.

The damage functions in the IAMs depart from those used in the traditional damage cost approach in ways that render them less reliable. The damage functions as used in a traditional damage cost approach as shown in Figure 1, below, involve a bottom-up method of calculating benefits from regulations.⁵⁸ However, the damage functions used in the IAMs are “simplified

⁵⁵ See Ex. 100, Schedule 2 at 2 (Polasky Direct Schedule 2, 2010 TSD).

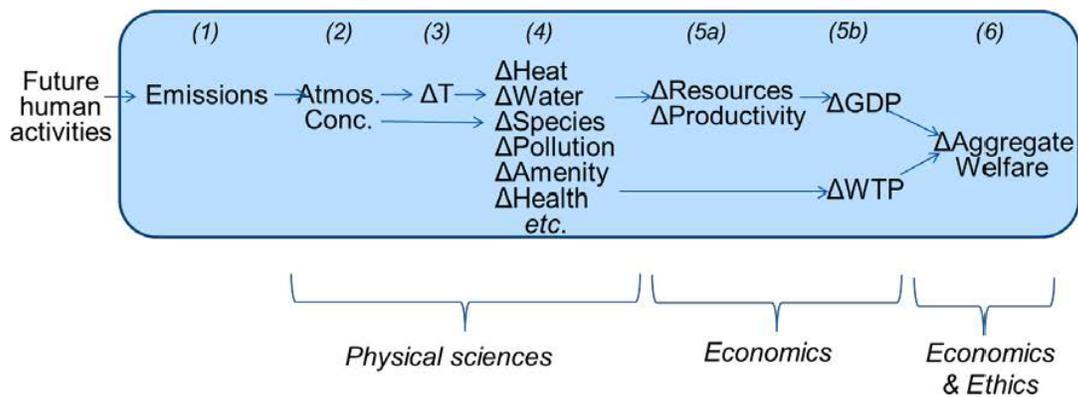
⁵⁶ *Id.* at 8.

⁵⁷ *Id.* at 9.

⁵⁸ Ex. 302 at 21 (Smith Report).

formulas” that do not use a full set of “dose-response” relationships between climate outcomes and monetary damages. The simplified or reduced form, like the one used to develop the Federal Social Cost of Carbon, is an aggregated damage function, as shown in Figure 2. The simplified damage functions used in the IAMs calculate damages directly from temperature change levels.⁵⁹ Although this aggregation is not necessarily inappropriate when the structure of the underlying relationships is well understood, it introduces a degree of speculation that is problematic in the context of resource planning where more precision is necessary.⁶⁰ This aggregation renders it very difficult to know what types of damages are included in a particular estimate.

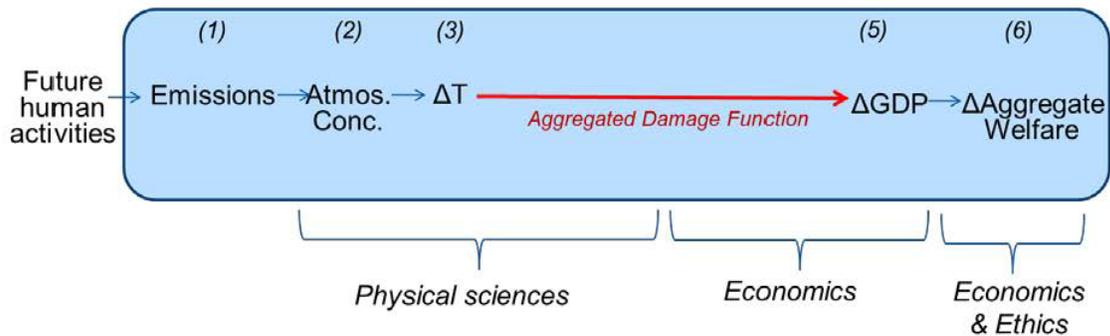
Figure 1. Climate Change IAM Structure Following a Traditional Damage Function Method



⁵⁹ *Id.* at 23; *see also* Ex. 801 at 39:18-40:22 (Hanemann Rebuttal) (agreeing that the IAMs do not employ conventional dose-response functions).

⁶⁰ *See* Ex. 300 at 19:16-20:5 (Smith Direct).

Figure 2. Structure of Climate Change IAMs Used for Estimating SCCs



The level of aggregation is particularly problematic in light of what the IWG has described as the “paucity” of data underlying the damage functions.⁶¹ As Dr. Smith noted, “there is very limited empirical basis for setting the parameters of the aggregated damage function, a condition acknowledged by the modelers.”⁶² Specifically, the available evidence is limited to historically observed temperature changes (i.e., less than 3°C).⁶³ Accordingly, for temperature changes above 3 degrees, the modelers must rely heavily on extrapolation. Specifically, “the damage functions are simple, smoothed curves fitted through some very limited empirical evidence associated with temperature changes of 3°C and less.”⁶⁴ As Dr. Smith noted, “[t]he assumed functional form (shape) of the damage curve, not data or sound economic reasoning, determines how large monetary values of damages would be for temperature changes exceeding about 4°C and reaching increases of over 17.5°C in some cases.”⁶⁵ MIT Professor Robert S. Pindyck also noted of the lack of empirical data underlying

⁶¹ Ex. 100, Schedule 2, at 8 (Polasky Direct Schedule 2, 2010 TSD).

⁶² Ex. 302, Attachment, at 3 (Smith Report Attachment, API Report) at 3.

⁶³ *Id.*

⁶⁴ Ex. 302 at 70-71 (Smith Report).

⁶⁵ *Id.* at 71.

the damage functions when he observed: “[W]e know almost nothing, so developers of IAMs can do little more than make up functional forms and corresponding parameter values. And that is pretty much what they have done.”⁶⁶

The level of extrapolation in the IAMs’ damage functions leads to wide variability in the possible estimates generated by these damage functions. As Dr. Smith noted, “[a]lthough the mathematical form of the damage function is relatively simple, plausible parameters for this mathematical formulation lead to very different estimates of global damages.”⁶⁷ She also found that “possible damage estimates at a given point in time can differ by a factor of 20 or more”⁶⁸

As a result of their aggregation of damages and the ungrounded assumptions about the impacts of temperature increases above 3 degrees, the damage functions contained in the IAMs are highly uncertain and extremely speculative, and that uncertainty and speculation is a particular problem when the IAMs are used to predict economic damages in the period after 2100. If the Commission were to adopt the Federal Social Cost of Carbon, it would be accepting values based upon speculative assumptions about the relationship between temperature increases above 3 degrees and the economy. The bottom line is the IAMs do not provide the level of precision that the Commission needs, or has required in the past, to establish the CO₂ value.

⁶⁶ Ex. 302, Attachment, at 2 (Smith Report). Similarly, Dr. Polasky characterized the extrapolation involved in the IAMs’ damage functions as a “best guess.” Hearing Transcript, Vol. 1 at 124:7-13 (Polasky).

⁶⁷ Ex. 302, Attachment, at 1 (Smith Report Attachment, API Report).

⁶⁸ *Id.* See also Ex. 302, Attachment at Figure ES-1, (Smith Report Attachment, API Report).

3. The damage estimates produced by the IAMs are highly speculative.

On one important issue, there is no real dispute: the witnesses agree the emission estimates relied upon by the IWG and the damages estimates developed through running of the IAMs, especially relating to the long modeling horizon period after 2100, are highly speculative. The disagreement lies in whether this degree of speculation is acceptable. To address this issue, the Commission must determine whether the economic framing assumptions used by the IWG are appropriate ones for use in establishing Minnesota's CO₂ value. In other words, even if the Commission should determine that reliance on the IAMs is reasonable, it still must take a hard look at the economic framing assumptions used by the IWG.

We believe it is important to recognize that the primary difference between the measure used by the Commission to establish CO₂ values and the measure used by the IWG to determine the Federal Social Cost of Carbon are the economic framing assumptions, rather than any significant advancement in scientific understanding.⁶⁹ The damage functions used by the IWG are based upon quantitative relationships between temperature changes and economic damages that are almost identical to those relied upon by the Commission to establish the CO₂ values in 1997.⁷⁰ In Figure 3 of her report, Dr. Smith provided a revealing comparison of the empirical evidence relied on by the Commission in 1997 and those scientific studies relied on in calibrating the damage function of the most recent versions of DICE. This comparison shows that “the

⁶⁹ When the CEOs filed their petition they alleged the environmental costs values were “no longer supported by scientific evidence.” *In the Matter of the Quantification of Environmental Costs*, Dockets No. E-999/CI-93-583, No. E-999/CI-00-1636, Memorandum in Support of Motion to Update Externality Values for Use in Resource Decisions (Oct. 9, 2013) at 13. The record in this proceeding does not support this claim.

⁷⁰ Ex. 302 at 26-27 (Smith Report). Notably, as Smith's Figure 3 shows, the studies used to support the most recent version of DICE examine warming up to 2.5°C, as did the estimates relied upon by the Commission in 1997. *Id.* at 27. Moreover, the results of those studies show similar effects on GDP. *Id.*

newer scientific studies since the 1990s that now serve as a basis for IAM damages functions have not substantively increased the estimates of likely damages from relatively small temperature increases.”⁷¹ Dr. Smith’s comparison also shows the newer scientific studies since the 1990s have not “provided scientifically-based data to inform the shape of the damage function at temperature increases above 3°C.”⁷² Dr. Smith goes on to conclude “[t]hus, even today, the basis for temperature changes in the range exceeding about 3°C remains an extrapolation from known data by the IAM developers.”⁷³

The undisputed evidence shows the damage functions in the IWG’s IAMs are still founded on limited empirical evidence.⁷⁴ As Dr. Smith observed, “[w]hat is new is the way that IWG has framed its analysis, causing the resulting SCC estimates to be much more heavily dependent on aspects of the IAM damage functions that are well beyond any evidentiary basis and much further into the realm of extrapolation and subjective judgment than the estimates made by Mr. Ciborowski [the MPCA’s witness, who offered testimony relied upon the Commission to establish the CO₂ value in 1997].”⁷⁵

(a) The Federal Social Cost of Carbon is based on three economic framing assumptions that are not consistent with those previously used by the Commission.

The differences in the recommendations made by Dr. Smith and the proposed Federal Social Cost of Carbon-based values result almost entirely from the use of the different economic

⁷¹ Ex. 302 at 28 (Smith Report).

⁷² *Id.*

⁷³ *Id.*

⁷⁴ Ex. 302 at 26-28 (Smith Report); Hearing Transcript Vol. 2B, at 91:15-92:4 (Hanemann).

⁷⁵ Ex. 302 at 7 (Smith Report).

framing assumptions. For three of the four economic assumptions – modeling time horizon, discount rate and marginal ton – Dr. Smith used the same essential assumptions that the Commission has made in establishing the current CO₂ value. There is no significant difference in the underlying science used in the damage functions relied upon by Dr. Smith and by the IWG.⁷⁶ The difference lies in the economic framing assumptions, and we believe the economic framing assumptions used by the IWG allow for too much speculation and fail to require reliable evidentiary support for the environmental cost values.⁷⁷

In the past, the Commission has deliberately avoided excessive speculation and never tolerated mere extrapolation in determining environmental cost values, and this has been clearly reflected in the choices that it made regarding the economic framing assumptions. The Commission currently only (i) estimates damages until 2100; (ii) applies discount rates in the range of 3 percent and 5 percent and (iii) calculates damages based on the damage estimated from an average ton. The Agencies and the CEOs are now proposing the Commission push out the time horizon to 2300, although there is no greater empirical evidence today than there was the 1990s to estimate emissions or damages in the period after 2100. Along with the time horizon, they are also proposing different approaches to the discount rate and the marginal ton analysis that, if adopted, will greatly increase the CO₂ environmental cost values and lack the evidentiary support that the Commission has required in previous proceedings.

We believe it is significant that if the Commission were to apply the same evidentiary standard in this investigation as it has did in the earlier environmental cost value proceedings, it would almost certainly determine the adoption of the Federal Social Cost of Carbon is not

⁷⁶ Ex. 302 at 7, 27-28 (Smith Report).

⁷⁷ *Id.*

reasonable. At a minimum, the Commission would find the economic framing assumptions relied upon by the IWG with respect to time-horizon, discount rate and marginal ton were inappropriate for use in updating the Minnesota CO₂ range of values, and primarily because the IWG's economic assumptions go too far in elevating the level of speculation in calculations and underlying analysis. We find it to be especially revealing that if the IWG had adopted the same economic framing assumptions as now used by the Commission, the range of CO₂ values would be approximately from \$8.75 (2014\$/net tonne, based on 5 percent discount rate) to \$20.97 (2014\$/net tonne, based on 3 percent discount rate),⁷⁸ as opposed to the range of \$12 to \$62 (for emissions year 2020) now proposed by the Agencies and the CEOs.⁷⁹

The range of environmental cost values for CO₂ determined using IAM modelling will largely be the result of choices made regarding the framing assumptions used in running the models. As Dr. Smith showed in her Table 4A, Exhibit 307, the choices made regarding the appropriate discount rate, time horizon, geographic scope of damages, and marginal ton of CO₂ considered, produce damage estimates that vary by more than \$45 per metric ton.⁸⁰ The results of Dr. Smith's sensitivity analysis reinforce a point made by Professor Pindyck:

With a judicious choice of parameter values (varying the discount rate is probably sufficient), the model will yield an SCC estimate as low as a few dollars per ton, as high as several hundred dollars per ton, or anything in between. Thus a modeler who, for whatever reason, believes that a stringent abatement policy is (or is not)

⁷⁸ Ex. 307 lines 35, 38 (Smith Table 4A) (assuming modeling horizon to 2100, discount rates of 3 percent and 5 percent, use of average ton for valuation, and global damages).

⁷⁹ Ex. 101 at 35:1-4 (Polasky Rebuttal); Ex. 801 at 87:22 (Hanemann Rebuttal). The figures presented use the average of the "first" and "last" marginal tons, which is the closest measure in the record to the average ton approach used in the prior proceeding. Ex. 302 at 61-62 (Smith Report).

⁸⁰ A metric ton emitted in 2020 with damages measured in 2014 dollars. Ex. 307 (Smith Table 4A).

needed, can choose a low (or high) discount rate, or choose other inputs that will yield the desired results.⁸¹

Because the framing assumptions used in the modelling drive the results, careful consideration must be given to the choice of these framing assumptions, none of which has a scientific basis.

For its modeling horizon, the IWG chose to run the IAMs through 2300 so that it might provide a more complete accounting of the emission damages.⁸² This would be appropriate for purposes of setting Minnesota's CO₂ value if there was reliable evidence upon which to forecast emission levels and socio-economic preferences 100 to 300 years into the future. But this is not the case. The IWG itself has recognized that "the trajectory of socioeconomic-emission scenarios beyond 2100 is uncertain."⁸³ The CEO's witness Dr. Stephen Polasky acknowledged that many of the future damage estimates were based on "guesswork." In addition, Mr. Martin pointed out that the methods the IWG used to extend forecasts to 2300 were not peer reviewed. He also observed that the IWG's assumptions were "largely arbitrary" and that those assumptions "drive all subsequent modeling steps (temperature response and damage estimation) after the year 2100."⁸⁴

In its analysis, the IWG also included a 2.5 percent interest rate, although this rate clearly lacks any substantial evidentiary basis. The IWG recognized there are two main approaches to choosing a discount rate for climate change analysis: the descriptive and prescriptive approaches.⁸⁵ Under the descriptive approach, the rate is chosen based on observations of how

⁸¹ See Ex. 600 at 46:8-15 (Martin Direct).

⁸² Ex. 100, Schedule 2 at 25 (Polasky Direct Schedule 2, 2010 TSD).

⁸³ Ex. 101, Schedule 1 at 29.

⁸⁴ Ex. 600 at 33:1-9 (Martin Direct).

⁸⁵ Ex. 100, Schedule 2 at 18 (Polasky Direct Schedule 2, 2010 TSD).

people actually make choices balancing future and current consumption, which generally involves using a market rate of return.⁸⁶ Under the prescriptive approach, the rate formalizes a normative decision as to how the value of the welfare of current generations should be weighed against the welfare of future generations.⁸⁷ That is, the rate itself is a choice based on how much the analyst determines one ought to discount future welfare. The IWG claimed to primarily rely on the descriptive method because it found the “approach to be the most defensible and transparent given its consistency with the standard contemporary theoretical foundations of benefit cost analysis and with the approach required by OMB’s existing guidance.”⁸⁸ Nonetheless, the IWG included a 2.5 percent rate in its analysis and supported this approach based on concerns about the uncertainty of interest rates over time and intergenerational equity.⁸⁹

The approach taken by the IWG relating to the modeling horizon and interest rate is entirely different than the one taken in the past by the Commission. Another striking example of the difference in approach is found in the recommendation made by Dr. Michael Hanemann, the Department of Commerce’s witness who suggested that the a risk premium should be included in the Social Cost of Carbon.⁹⁰ In effect, Dr. Hanemann is proposing a contingency, without any evidence whatsoever, to ensure that all damages are counted. For good reason, the Commission rejected this approach in early proceedings.⁹¹ The Commission has recognized that some

⁸⁶ *Id.*

⁸⁷ *Id.*

⁸⁸ *Id.*

⁸⁹ *Id.*

⁹⁰ Ex. 801 at 60:17-62:21 (Hanemann Rebuttal).

⁹¹ ALJ Findings ¶ 106; January 3, 1997 Commission Order at 27.

damages cannot be monetized because there is a lack of sufficient evidence.⁹² The Commission has further recognized that the failure to monetize certain future damages does not mean those damages are being ignored but only that they cannot be captured for purposes of quantification for consideration in the resource planning process.⁹³

B. An Adjusted Social Cost of Carbon is a Better Alternative.

The Commission directed that if the Federal Social Cost of Carbon is not “reasonable and the best available measure” to determine the environmental cost values of CO₂, the next question for these proceedings is “what measure is better supported by the evidence.”⁹⁴ The adjusted social cost of carbon values recommended by Dr. Smith are a better alternative for use in utility resource planning in Minnesota because they fit with the approach for establishing cost values taken by the Commission in the prior proceeding, and are more consistent with applicable principles of benefit-cost analysis. The adjustments made by Dr. Smith result in values more tied to the evidence of the impacts of climate change and the actual economic trade-offs made by market participants, and better reflect the realities of Minnesota’s relationship with the rest of the world.⁹⁵

⁹² ALJ Findings ¶ 144 (concluding that mercury damages could not be quantified due to the absence of sufficient evidence).

⁹³ *Id.* at Discussion of Policy Issues section, at pp. 17-18 of 47 of pdf file.

⁹⁴ Notice and Order for Hearing at 8.

⁹⁵ We recommend the Commission should not accept the range of values presented by Nicholas Martin of Xcel Energy. Mr. Martin did not make any changes to IWG’s framing assumptions, Ex. 303 at 3:17-20, 10:8-11:11 (Smith Rebuttal). In addition, the statistical technique proposed by Mr. Martin and Xcel Energy’s consultants is not consistent with any recognized and accepted statistical method. Ex. 240, Exhibit. 2 (Wecker Rebuttal Report) at 119-215; Ex. 303 at 6:8-7:4 (Smith Rebuttal).

In supporting Dr. Smith's analysis, we are not recommending any adjustment to the manner in which the IWG modelled the physical relationship between CO₂ emissions and changes in the climate. Witnesses sponsored by Peabody Energy have questioned whether and to what extent carbon dioxide emissions contribute to the warming of the planet and have challenged the reliability of the climate models used by the Intergovernmental Panel on Climate Change ("IPCC"). We are not proposing that environmental cost values for CO₂ be based on anything other than those IPCC positions on climate change incorporated by the IWG into its operations of the DICE, FUND, and PAGE models.

Dr. Smith has identified and made adjustments to certain key economic framing assumptions used by the IWG based on Minnesota law and Commission precedent, as well as and sound principles of environmental economics and benefit-cost analysis. The framing assumptions in question are: the time horizon, the discount rate, the marginal ton, and the geographic scope of damages, each of which is discussed below.⁹⁶

1. Time Horizon

The IWG's Social Cost of Carbon is based on modelling that predicts damages incurred and carbon emitted through to the year 2300, which is 285 years in the future. No prediction or forecast of future conditions, even a short-term one, is certain, and we are not aware of any witness or party who testified otherwise. However, as Professor Polasky recognized, the uncertainty increases the further into the future one seeks to forecast.⁹⁷ An attempt to predict

⁹⁶ We urge the Commission to adopt the recommendations offered by Dr. Smith. However, if the Commission should come to a different determination with respect to any of the economic framing assumptions, Dr. Smith presents the environmental cost values resulting from 48 different combinations of framing assumptions, and the Commission can use that table to establish and its range of environmental cost values for carbon dioxide. Ex. 307 (Smith Table 4A).

⁹⁷ Hearing Transcript, Vol. 1, 90:8-11 (Polasky).

economic conditions and emissions over the next 285 years is subject to much greater uncertainty than an attempt to predict economic conditions and carbon emissions over the next 85 or 125 years. The only thing we can say with any certainty about the structure of global societies and economies 150, 200, 250, and 285 years from now is that they will be different in ways we cannot predict. To illustrate the point, Dr. Smith offered the thought experiment of imagining how well persons in the early 1700s would have done if they had to forecast conditions today.⁹⁸ Someone in the 1700s seeking to quantify future damages from a warming of the planet might have placed some emphasis, for example, on figuring out what impact warming would have on horses given their importance for transportation. In making predictions today about the extent to which warming will cause damages in 2200 or 2300, we are likely to make similar errors. We do not know what technologies or sectors of the economy will be important in the future or how sensitive those unknown technologies and sectors will be to heat.

Not surprisingly, no party to this proceeding provided any evidence suggesting economists or modelers have an ability to make long-term predictions with any reasonable degree of accuracy. Instead of claiming they had evidence upon which reasonably accurate predictions could be made, the argument given by witnesses favoring the adoption of the Federal Social Cost of Carbon as Minnesota's range of environmental cost values was that the models should be run until 2300 because carbon dioxide lingers in the atmosphere and so a shorter cut-off date would leave out some portion of the damage from current emissions.⁹⁹ This argument, however, misses the point. Under Minnesota law, damages are only included to the extent they

⁹⁸ Ex. 302 at 74 (Smith Report).

⁹⁹ *E.g.*, Ex. 101 at 15:5-20 (Polasky Rebuttal) (“Properly estimating the marginal damages associated with a unit of emission of CO₂ requires accounting for the impact of that unit as far into the future as it is likely to remain in the atmosphere and cause damages.”).

can be practicably quantified, which requires some evidentiary basis. It is not enough for proponents of the Federal Social Cost of Carbon to say that damages are likely to occur through 2300. If that were the case, the Commission would have adopted a range of values for mercury emissions in the last proceeding. Rather, the question is whether damages which occur out to 2300 can be estimated with sufficient certainty so as to satisfy the requirements of Minnesota law and precedent. Damages which cannot be adequately quantified based on current evidence, such as far-future damages, can still be considered qualitatively in resource planning.¹⁰⁰

Of course, any prediction of future events involves some degree of speculation. Even the 2100 horizon accepted by the Commission last time and recommended by Dr. Smith as one of the framing assumptions to use in determining Minnesota's range of values requires speculation. That is also true of the 2140 horizon suggested by Dr. Smith. After all, we only have evidence of current and past conditions. However, the 2100 and 2140 horizons recommended by Dr. Smith are tied to technology cycles. Long-lived technologies, like electrical generation plants, tend to have an economic life of no more than 80 years, and predictions of what technologies will be used in the future based on current understandings might add another 40 years to this period.¹⁰¹ Predictions of conditions in 2100 and 2140 have some connection to what we know about current and anticipated technologies, but beyond that point we move into a realm that is largely unknowable.¹⁰²

In addition to the general and extreme uncertainty inherent in long-range forecasting, the 2300 model horizon is also problematic because of how far it departs from the evidence we have

¹⁰⁰ ALJ Findings, at Discussion of Policy Issues section, p. 17-18 of 47 of pdf file.

¹⁰¹ Ex. 302 at 75 (Smith Report).

¹⁰² *Id.*

today of the impact temperature increases have on the economy. Simply put, we have no empirical evidence of how temperature increases of more than 3 degrees affect the economy. And the proponents of the Federal Social Cost of Carbon have not suggested otherwise. Instead, as Dr. Polasky explained, the economic damages modeled for heating of more than that amount are merely a “best guess.”¹⁰³ The IWG also recognized the lack of evidence regarding the impact of higher temperature changes upon GDP. In its 2010 Technical Support Document, the IWG observed that because the damage functions of the IAMs were calibrated based on estimates of the economic damage from moderate temperature increases, “estimated damages are far more uncertain under more extreme climate change scenarios.”¹⁰⁴

When damages are calculated using a 2300 model horizon, however, many of the model runs involve temperature increases well beyond 3 degrees. As Dr. Smith explained in her report, approximately half of the model runs underlying the Federal Social Cost of Carbon figures have temperature increases between 3.5 °C and 4.5 °C by 2100, between 4.8 °C and 7.7 °C by 2200, and between 5.2 °C and 9.0 °C by 2300.¹⁰⁵ About ten percent of the model runs underlying the IWG’s values have temperature increases of between 4.5 and 9.4 °C by 2100, between 7.7 °C and 15.2 °C by 2200, and between 8.9 °C and 17.5 °C by 2300.¹⁰⁶ This lack of evidence regarding the impact of higher temperatures compounds the uncertainty resulting from lack of knowledge as to the economic conditions and technologies that will be in place more than 100 or 140 years from now. Mr. Martin recognized that the “further out in time, and the greater the temperature

¹⁰³ Hearing Transcript, Vol. 1, 124:7-13 (Polasky).

¹⁰⁴ Ex. 100, Schedule 2 at 30 (Polasky Direct Schedule 2, 2010 TSD).

¹⁰⁵ Ex. 302 at 72 (Smith Report).

¹⁰⁶ *Id.*

changes, for which the IWG attempts to calculate the SCC, the more disconnected the IAM damage functions become from any empirical basis.”¹⁰⁷ When the model horizon of 2300 is used, the models produce damage estimates that are “far more uncertain” and are based on a “best guess” as to the relationship between higher temperature rises and the economy.

Finally, the IWG’s use of a 2300 modelling horizon is not appropriate for use in Minnesota because it incorporates unrealistic assumptions about how humans will respond to climate change even after experiencing sometimes dramatic increases in temperature. Of the five IWG scenarios, one is a stabilization scenario in which emissions are contained such that atmospheric concentration of CO₂ is limited to 550 parts per million.¹⁰⁸ However, none of the IWG modelling included the possibility of technological changes made in response to rising temperatures to alter the climate, provide better adaptation to higher temperatures, or even lower emissions (perhaps by adopting more efficient technologies or different methods of electricity generation, both of which seem like reasonable possibilities over the next 285 years) in response to temperature changes.¹⁰⁹ Instead, it is assumed that a global society that is wealthier than today’s will experience potentially dramatic temperature increases, with half of the model runs showing 3.5 °C to 4.5 °C increases by 2100 as discussed above, but will not act to mitigate these effects. It is presumed that society will not respond by putting some of those greater resources (and whatever superior scientific and technological knowledge may have developed) into developing new methods to reduce the harm caused by temperature increases.¹¹⁰ To put this into

¹⁰⁷ Ex. 601 at 44:7-14 (Martin Rebuttal).

¹⁰⁸ Hearing Transcript, Vol. 3B, 110:1-23 (Martin).

¹⁰⁹ *See id.* at 110:1-112:7.

¹¹⁰ Ex. 302 at 73 (Smith Report); Ex. 600 at 34:8-17 (Martin Direct).

perspective, consider “that the IAMs are modelling a time period (present to the year 2300) that is significantly longer than the time that has elapsed from the Industrial Revolution to the present” a period during which technology has changed tremendously.¹¹¹ Even today, there are efforts to find ways to reduce the likelihood or harm of global warming, and we should expect greater efforts from future societies that have lived through actual warming far beyond what we may have experienced to date.¹¹² The IWG’s assumptions are not realistic, inflate the damages from carbon dioxide emissions,¹¹³ and further cast into doubt the reasonability of the IWG’s far-future modelling runs.

Given the lack of reliability of values produced using the 2300 modelling horizon as a result of the inherent uncertainty in far-future predictions, the lack of evidence of how higher temperature increases impact the economy, and the unrealistic assumption that there will not be a technological response after temperatures have risen significantly, the Commission should not adopt the IWG’s range of values. Instead, as recommended by Dr. Smith, the Commission should adopt values calculated using model horizons of 2100 and 2140, which is consistent with the 2100 end-date used in the prior proceeding. The 2100 and 2140 horizons are recommended not because it is claimed there are no damages after that point, but rather because “beyond that time the degree of speculation becomes too great to be appropriate for determining near-term financial investments in Minnesota’s electricity power system.”¹¹⁴ The forecasts out to those years can at least be tied to what we know about current and forthcoming technologies, and the

¹¹¹ Ex. 600 at 34:13-17 (Martin Direct).

¹¹² Ex. 601 at 48:17-22 (Martin Rebuttal).

¹¹³ Ex. 216 at 16:24-17:6 (Mendelsohn Direct) (“By assuming society will never mitigate greenhouse gasses, the IWG has overblown the harm from greenhouse gasses”).

¹¹⁴ Ex. 304 at 20:4-6 (Smith Surrebuttal).

damages calculated are less based on mere guesswork as to how temperature increases above 3°C will impact GDP. This approach reduces uncertainty as “shortening the modeling horizon truncates the time period of the most uncertain results.”¹¹⁵ Moreover, the time horizons used by Dr. Smith do not require the Commission to assume that after having experienced temperature increases above 3°C the people of the future will simply allow the temperature to continue to rise for hundreds of years without developing some technologies to mitigate the impact by altering the climate, reducing emissions, or improving adaptation to the higher temperatures.

2. Discount Rate

The IWG’s Social Cost of Carbon was determined using discount rates of 2.5 percent, 3 percent, and 5 percent. When analyzing proposed rules with both intra- and intergenerational effects, Federal agencies traditionally use discount rates of both 3 percent and 7 percent.¹¹⁶ Although policies impacting carbon dioxide emissions would seem to have both intra and intergeneration effects, the IWG nonetheless chose not to use the typically recommended 7 percent rate.

The 3 and 5 percent rates were the two rates used to calculate the range of CO₂ values set in the prior proceeding.¹¹⁷ At that time, the Commission was urged to use rates below 3 percent, as it is today, based on intergenerational considerations, but it declined to do so based on a lack of evidentiary support for such rates in the record.¹¹⁸ The same 3 percent and 5 percent rates used by the Commission were later adopted by the IWG, which explained they were based on

¹¹⁵ Ex. 601 at 28:18-22 (Martin Rebuttal).

¹¹⁶ Ex. 100, Schedule 2 at 17 (Polasky Direct Schedule 2, 2010 TSD).

¹¹⁷ January 3, 1997 Commission Order at 27.

¹¹⁸ *Id.*

evidence of individuals' post-tax riskless and risky consumption rates.¹¹⁹ In other words, the selection of those rates had reasonable evidentiary support because they were based on observations of how people actually value future benefits when making financial decisions.¹²⁰

In contrast to the higher rates, the IWG explained the 2.5 percent discount rate was partially adopted as a response to ethical objections that have been raised to using discount rates of 3 percent or higher.¹²¹ As discussed above, this is what is known as the prescriptive approach in which the discount rate is set based on how proponents judge current and future welfare should be weighed against each other. The 2.5 percent rate was also meant to incorporate a theoretical concern about the uncertainty of interest rates over time.¹²² In contrast to the 3 percent and 5 percent discount rates, inclusion of the 2.5 percent rate is was not supported with evidence of actual human behavior.

In addition to not having a reliable evidentiary basis, the 2.5 percent rate is also problematic for policy and ethical reasons. The prescriptive argument for using a lower rate is that it is unethical for one generation to unduly discount the welfare of future generations when making decisions today. It could be boiled down to the idea that one should be careful not to treat the welfare of people tomorrow as less valuable (or too much less valuable) than the welfare of people alive today. However, "the problem with this argument is that global warming projections all assume that future generations will be wealthier than we are."¹²³ In fact, the

¹¹⁹ Ex. 100, Schedule 2 at 20, 23 (Polasky Direct Schedule 2, 2010 TSD).

¹²⁰ *Id.* at 18.

¹²¹ *Id.* at 23.

¹²² *Id.*

¹²³ Exhibit 218 (Mendelsohn Rebuttal), Exhibit 1 at 7:151-8:162.

emissions from those future, higher-income generations drive much of the Federal Social Cost of Carbon values.¹²⁴ By lowering the discount rate below market rates, advocates for the lower rates are encouraging policies “shifting the burden of paying for climate change away from these future wealthier generations and putting the cost instead on the present generations.”¹²⁵

The use of a non-empirical, or prescriptive, discount rate is also problematic because it distorts decision-making. At any given time, capital can be invested in various public and private projects which might increase welfare in various ways, including by reducing carbon dioxide emissions. Because the discount rate reflects the likely return on these investments, the use of low discount rate implicitly reflects a lower return on related investments.¹²⁶ Therefore, if a low discount rate is used when analyzing carbon emissions reductions issues in resource planning, but the same low rate is not also used in other private or public investments (including investments in education, national defense, or infrastructure), policy makers would be implicitly assuming that it is acceptable to get that lower rate as the rate of return on emission-reduction projects.¹²⁷ The use of an interest rate below 3 percent can result in investments being made in emissions reductions projects rather than other, potentially more beneficial projects.¹²⁸

The IWG, of course, also pointed to uncertainty about interest rates changing over time as another basis for the 2.5 percent rate.¹²⁹ However, this theoretical consideration does not justify

¹²⁴ *Id.*

¹²⁵ *Id.*; *see also* Ex. 302 at 87-88 (Smith Report).

¹²⁶ Ex. 216 at 11:14-26 (Mendelsohn Direct).

¹²⁷ *Id.*

¹²⁸ Ex. 218, Exhibit 1 at 5:101-6:107 (Mendelsohn Rebuttal)

¹²⁹ Ex. 100, Schedule 2 at 22 (Polasky Direct Schedule 2, 2010 TSD).

the lower rate. All of the IWG's rates, which are based only on consumption and not on capital rates, are too low because they do not account for the opportunity costs associated with using scarce capital to reduce emissions.¹³⁰ Accordingly, even if the 2.5 percent rate could be characterized as an empirically-derived rate, which is not accurate, it would still be too low.

We urge the Commission to make the same choice it made last time and use the 3 percent and 5 percent discount rates. The 2.5 percent rate is not supported by either the evidence of how people actually behave or the ethical arguments made by its proponents. The use of this rate inflates the range of environmental cost values, may distort current decision-making, and would be particularly harmful if used in conjunction with the 2300 modeling horizon proposed by the IWG as hundreds of years of speculative damages which are not adequately discounted would then be included in the range of values.

3. Marginal Ton

Unlike the modeling horizon and discount rate, the choice of which ton to use in calculating the damages from carbon dioxide emissions is not a question of the extent to which a framing assumption is tied to evidence. Rather, the issue is the appropriate choice of assumptions given principles of environmental economics and cost-benefit analysis. In the last proceeding, the Commission adopted values based on the damage caused by an average emitted ton.¹³¹

The IWG did not use an average ton approach. Instead, it used a marginal ton approach, and, more particularly, a "last ton" version of a marginal ton approach when it estimated the damages resulting from a ton of carbon dioxide emitted in a given year. The IWG ran the IAMs

¹³⁰ Ex. 304 at 26:17-28:8 (Smith Surrebuttal).

¹³¹ Ex. 302 at 8, 54 (Smith Report); January 3, 1997 Commission Order at 27.

to determine the difference between a “business as usual” baseline projection that includes all the past, current, and projected future CO₂ emissions and that same baseline plus the additional ton of emissions in the year in question.¹³² For example, the Federal Social Cost of Carbon value for 2020 is based on the damages resulting from the concentration of CO₂ expected to exist by 2020, all CO₂ emissions produced in 2020, and all CO₂ emissions projected to occur in the model’s scenarios from 2020 to 2300.¹³³ Accordingly, if this approach is used to calculate Minnesota’s range of environmental cost values, the result is that a ton of CO₂ emitted in Minnesota in a given year is valued as the single most harmful ton in the entire global inventory of tons of CO₂ emitted over a period of up to almost 300 years. This method “is likely to overstate the damages” from Minnesota’s emissions.¹³⁴ In reality, of course, Minnesota’s emissions are no more or less harmful than tons emitted in any other jurisdiction.

In addition to treating Minnesota emissions as more harmful than carbon emitted elsewhere, the use of a “last ton” approach in Minnesota is inappropriate because it assumes any reduction in carbon emissions resulting from the use of Minnesota’s environmental cost values occur in isolation.¹³⁵ That is, no other reductions are assumed other than those reductions already included in the five scenarios used by the IWG.¹³⁶ Of course, Minnesota’s

¹³² Ex. 300 at 20:8-18 (Smith Direct).

¹³³ *Id.* at 20:18-21.

¹³⁴ Ex. 602 at 30:22-31:3 (Martin Sur-rebuttal).

¹³⁵ Ex. 302 at 53 (Smith Report).

¹³⁶ *Id.*

environmental cost values will have no appreciable benefit unless Minnesota's reduced emissions occur in concert with emission reductions elsewhere.¹³⁷

Rather than unduly penalize Minnesota by treating its emissions as unduly harmful, the Commission should base its values on the "first ton" scenarios in which the harm from given tons is not considered in connection with other projected emissions¹³⁸ and the average of the "first ton" and "last ton" which approximates an approach in which Minnesota's reductions occur along with emissions reductions in other jurisdictions.¹³⁹

Other witnesses have suggested that Dr. Smith is assuming no emissions will occur after 2020, which all parties recognize is an unrealistic scenario. But these witnesses miss the point. The "first ton" approach is merely an analytic exercise designed to separate out the extent to which damages result from historical emissions as opposed to emissions that have not yet occurred.¹⁴⁰

The average marginal ton approach has the benefit of being consistent with the approach typically taken by environmental economists when calculating externalities in which the particular marginal ton to be valued is based on an optimal emissions scenario.¹⁴¹ Finally, if the Commission wishes to base the range of values on damage from an average ton and not a

¹³⁷ *Id.*

¹³⁸ *Id.* at 61, 64.

¹³⁹ *Id.* at 64.

¹⁴⁰ Ex. 304 at 22:2-23:4 (Smith Surrebuttal).

¹⁴¹ *Id.* at 55-60, 64.

marginal ton, as it did in the prior proceeding, then the average of the first and last marginal tons should be adopted as the closest approximation.¹⁴²

4. Geographic Scope

The Federal Social Cost of Carbon was developed using estimates of global damage resulting from carbon dioxide emissions, and not just damages in Minnesota or the United States. Unlike the other economic framing assumptions, the Commission's concern with having evidentiary support for its costs values does not compel a decision regarding the appropriate geographic scope. The Commission decided in the last proceeding to adopt a range of values calculated using global damages.¹⁴³ Nonetheless, we believe the most sensible course for Minnesota to take is to limit the damages included in its environmental cost values to U.S. domestic damages.

Limiting the environmental cost values to only include domestic damages is consistent with sound principles of cost-benefit analysis.¹⁴⁴ Political jurisdictions typically evaluate proposed policies or courses of action based on the benefits and costs that will be incurred within that jurisdiction.¹⁴⁵ The Office of Management and Budget's Circular A-4, for example, indicates federal regulatory cost-benefit analyses should "focus on benefits and costs that accrue to citizens and residents of the United States."¹⁴⁶

¹⁴² Ex. 302 at 61-62 (Smith Report).

¹⁴³ January 3, 1997 Commission Order at 15.

¹⁴⁴ Ex. 400 at 7:11-13 (Gayer Direct).

¹⁴⁵ Ex. 400, Appendix 2 at 4 (Gayer Report).

¹⁴⁶ *Id.* at 9.

One recognized exception to the usual practice of only considering domestic damages is those situations in which there is reciprocity. Minnesota, however, is not acting in concert with other jurisdictions in this matter. Other states and countries have not agreed to consider damages to Minnesota when making utility resource planning decisions. Consequently, if Minnesota imposes burdens on itself, perhaps through the selection of more costly utility options, it will not be doing so as part of some broader effort by state actors. By unilaterally taking account of global damages, Minnesota may impose substantial costs on its citizens and residents in the form of more expensive electrical rates in return for little to no benefit to either Minnesota or the global community.¹⁴⁷ Any meaningful progress in slowing global climate change will require coordinated global action, and even a complete elimination of damages in Minnesota will have almost no impact.¹⁴⁸

C. Adjustments for Leakage Should be Applied in Resource Planning.

The evidence shows that the “unilateral application by Minnesota of CO₂ environmental cost values, without corresponding action by other states, is likely to result in shifting of emissions that will at least partially offset emission reductions within Minnesota.”¹⁴⁹ This could occur by businesses relocating in search of lower energy costs, or through re-dispatch of energy through an interconnected system like the Midcontinent Independent System Operator (“MISO”). As Mr. Martin noted, “if the CO₂ environmental cost values drive the decision to retire a fossil unit, that unit’s generation would be replaced in the short term through the

¹⁴⁷ Ex. 601 at 39:20-40:12 (Martin Rebuttal).

¹⁴⁸ We note that the Commission is not limited to either wholly including or wholly excluding non-U.S. damages from the range of environmental cost values, and could choose to give partial weight to non-U.S. damages.

¹⁴⁹ Ex. 601 at 52:15-53:2 (Martin Rebuttal).

rebalancing of the MISO system with other generation, some of which would likely be fossil generation located outside of Minnesota. This type of emissions leakage . . . would be relatively immediate, automatic and difficult to avoid.”¹⁵⁰

Leakage is not merely a theoretical concern. Dr. Smith testified that “[l]eakage is likely to occur when one state adopts a policy that drives up the cost of energy production in that state, while the cost of energy production in neighboring states remains unchanged.”¹⁵¹ Dr. Polasky agreed that leakage should be taken into account in resource planning.¹⁵² No witness denied leakage is likely to occur.

The Commission should reject the argument advanced by Dr. Hanemann, who, while not denying that leakage might occur, argued that there should be no adjustment for leakage, because the Commission is not responsible for regulating the level of greenhouse gas emissions in other states or in the United States.¹⁵³ While it is true that the Commission cannot order emissions reductions in other states, the Commission can account for emissions increases in other states directly caused by actions in Minnesota when evaluating resource decisions in Minnesota.

A failure by the Commission to properly account for leakage will result in either a failure to measure the full environmental cost, or an overstatement the environmental benefit, of resource planning decisions in Minnesota. Therefore, we recommend the Commission adopt the proposal made by Dr. Smith that a specific leakage ratio be calculated in individual resource planning dockets, and that Minnesota’s environmental cost value should be applied only to the

¹⁵⁰ *Id.* See also Ex. 300 at 27:16-28:2 (Smith Direct).

¹⁵¹ Ex. 300 at 28:13-17 (Smith Direct).

¹⁵² Hearing Transcript 1 at 125:20-126:9 (Polasky).

¹⁵³ Ex. 801 at 30:26-31-2 (Hanemann Rebuttal).

net reduction in CO₂ emissions which may result from Minnesota resource decisions, after adjusting for emissions increases that may occur elsewhere as a result of Minnesota's actions.¹⁵⁴

VI. CONCLUSION

The preponderance of the evidence presented does not support the adoption of the Federal Social Cost of Carbon. The proponents of those values have not shown that it is more probable than not that the Federal Social Cost of Carbon is a reasonable and the best available measure of the environmental cost of CO₂. The lack of evidence supporting crucial portions of the projected damages; the relative lack of an empirical basis for the 2.5 percent discount rate; the lack of adequate rationale supporting the marginal ton; and an unrealistic geographic scope all support that the Federal Social Cost of Carbon values are not appropriate for use in Minnesota. In contrast, the preponderance of the evidence supports the adoption of the range of values proposed by Dr. Anne E. Smith, which was calculated using a modified version of the IWG's methodology which is much less speculative with regard to predictions regarding far future economic impacts and the economic damage from temperature increases greater than 2 or 3 degrees Celsius. After carefully considering the framing assumptions that best comport with Minnesota law, Commission precedent, and sound principles of cost-benefit analysis and environmental economics, the Commission should establish a range of environmental cost values for CO₂ of \$1.62/net metric tonne to \$5.14/net metric tonne (2014\$ for emission year 2020) as recommended by Dr. Smith. We also recommend the Commission adopt policies that will account for leakage in the resource planning process.

¹⁵⁴ Ex. 300 at 28:19-22 (Smith Direct).

Dated: November 24, 2015

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